

# Chitons (Mollusca: Polyplacophora) associated with hydrothermal vents and methane seeps around Japan, with descriptions of three new species\*

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**Abstract:** Three new species of chitons are described from hydrothermal vent sites and methane seep sites around Japan: *Deshayesiella sirenkoi* n. sp. from the hydrothermal vent sites on the seamounts in the northern Mariana Islands area, *Placiphorella okutanii* n. sp. from Hachijo Depression in the Izu-Ogasawara (Bonin) Islands area where no active vent/seep area has been discovered, but the possibility of hydrothermal activity has been suggested, and *Placiphorella isaotakii* n. sp. from methane seep sites on the Kuroshima Knoll off Yaeyama Islands. *Deshayesiella sirenkoi* n. sp. as well as two previously known hydrothermal vent species, *Leptochiton tenuidontus* Saito and Okutani, 1990 and *Thermochiton undocostatus* Saito and Okutani, 1990, are vent/seep associated species, whereas the two *Placiphorella* may be guest species. Additional distributional records are given for the two known species.

**Key words:** *Deshayesiella*, *Placiphorella*, deep-sea, chemosynthetic environment, taxonomy, Pacific Ocean

The number of the molluscan taxa described from chemosynthetic environments has rapidly increased in the last two decades (Sasaki *et al.* 2005). Most of these taxa are, however, gastropods and bivalves (Desbruyères *et al.* 2006: 520–523). Since Saito and Okutani (1990) described two chiton species from the hydrothermal vent site of Okinawa Trough, East China Sea, some chiton species have been reported from chemosynthetic environments. Squires and Goedert (1995) reported *Leptochiton alveolus* (Lovén, 1846) (*sensu* Ferreira 1979 and Kaas and Van Belle 1985) from Eocene and Oligocene cold methane seep limestones, Olympic Peninsula, Washington. Olu *et al.* (1997) reported “Polyplacophora” from the methane seep of Barbados Prism, 1,000–2,000 m, and Sellanes *et al.* (2004) reported *Leptochiton* sp., *Stenosemus* sp., and *Placiphorella* sp. from methane seepage in the bathyal zone off Chile. Schwabe and Sellanes (2004) have described a new species, *Lepidozonia balenophila*, from another type of chemosynthetic environment, decomposing whale carcasses. However, no vent/seep associated chiton species, other than the two known species, has been described anywhere else in the world. Those two known species that were described from the hydrothermal vent in the East China Sea are *Leptochiton tenuidontus* Saito and Okutani, 1990 and *Thermochiton undocostatus* Saito and

Okutani, 1990. They were collected by a human-occupied submersible, *Shinkai 2000*, belonging to Japan Agency for Marine-Earth Science and Technology (JAMSTEC). Since then, some additional chiton specimens have been collected from Japanese waters by the Deep Sea Research System, including human-occupied submersibles or ROVs belonging to JAMSTEC. Here, we describe three new species and further describe the morphology and distribution of the two previously known species.

## MATERIALS AND METHODS

Specimens were collected by the Deep-sea Research System of JAMSTEC: human-occupied submersibles *Shinkai 2000* (abbreviated as 2K) and *Shinkai 6500* (6K) and a remotely operated vehicle *Hyper-Dolphin* (HPD). Sampling sites are shown in Fig. 1. Preparation for SEM observation followed Saito (2006). All specimens were deposited in the molluscan collection of the Department of Zoology, National Museum of Nature and Science (formerly National Science Museum, Tokyo) (NSMT).

The systematic arrangement used in this paper follows Sirenko (2006).

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## SYSTEMATICS

Order Lepidopleurida Thiele, 1909  
 Suborder Lepidopleurina Thiele, 1909  
 Family Leptochitonidae Dall, 1889  
 Genus *Leptochiton* Gray, 1847

## Type species

*Chiton cinereus* Montagu, 1803 [= *Leptochiton asellus* (Gmelin, 1791)], by subsequent designation (Gray, 1847).

*Leptochiton tenuidentus* Saito and Okutani, 1990  
 (Fig. 2A-B)

*Leptochiton tenuidentus* Saito and Okutani 1990: 166-171, figs. 2-12, pl. 1, figs. 1-4; Kaas and Van Belle 1994: 22-23, fig. 7; Kaas and Van Belle 1998: 185; Saito 2000: 7, pl. 3, fig. 11; Cosel 2006: 81.

*Leptochiton* sp. Saito and Fujikura 2000: 74-75.

## Type material examined

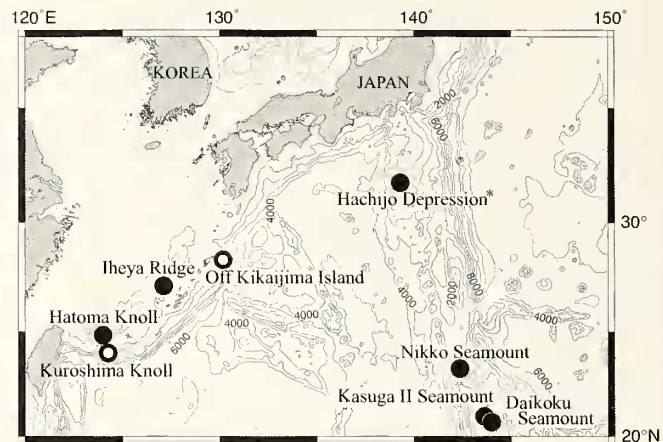
Holotype: NSMT-Mo 69193, body length ca. 16 mm. Type locality: hydrothermal vent site on the Iheya Ridge, central Okinawa Trough, East China Sea, 27°32.70'N, 126°58.20'E, 1395 m, 2K, Dive #426, 21 July 1989.

## Additional material examined

NSMT-Mo 73838 (ex. JAMSTEC sample No.: RK4-A-1, 009550-009553), 4 specimens, body length ca. 18-20 mm, methane seep site off Kikaijima Island in the Amami Islands area, 28°26.39'N, 130°19.01'E, 1430 m, 2K, Dive #1020, 24 June 1998; NSMT-Mo 73839 (ex. JAMSTEC sample No.: RK4-A-1, 009548-009549), 2 specimens, body length 22 and 23 mm, methane seep site off Kikaijima Island in the Amami Islands area, 28°26.42'N, 130°18.98'E, 1442 m, 2K, Dive #1021, 25 June 1998; NSMT-Mo 73940 (ex. JAMSTEC sample No.: RK4-A-1, 009544-009547), 3 specimens, body length ca. 20-22 mm, methane seep site off Kikaijima Island, in the Amami Islands area, 28°26.45'N, 130°19.1'E, 2K, Dive #1022, 1440 m, 26 June 1998. All nine specimens were found on the shells of *Bathymodiolus platifrons* Hashimoto and Okutani, 1994.

## Additional description

Tegmentum sculptured with round granules densely arranged in quincunx order on head valve, lateral areas of median valves, and postmucronal area of tail valve, with elongate granules arranged in quincunx order or, occasionally, in irregular longitudinal rows in central area of median valves and antemucronal area of tail valve (Fig. 2A). Each granule with one macroaesthete pore and one to four microaesthete pores on anterior slope; size of macroaesthete pore ca. 5-8  $\mu$ m, that of microaesthete pore slightly smaller than macroaesthete pore (Fig. 2B).



**Figure 1.** Sampling sites. Solid circles indicate hydrothermal vent. Open circles indicate methane seep. \*No active vent/seep area has been discovered but the possibility of hydrothermal activity has been suggested.

Gills merobranchial, adanal, without interspace, 6-8 on each side.

## Distribution and type of habitat

Iheya Ridge and off Kikaijima Island, Nansei Islands, 1395-1442 m; hydrothermal vent and methane seep.

## Remarks

This species was described based on a single specimen with heavily eroded valves missing a large part of the tegmental sculpture. The remaining small portion of sculpturing and other features, especially the characteristic radula with elongate "toothpick"-like inner small (third) lateral, allows the additional specimens to be identified as this species.

The holotype was collected from undersurface of a rock, whereas all additional specimens were attached on the shells of *Bathymodiolus platifrons*.

Family Protochitonidae Ashby, 1925

Genus *Deshayesiella* Carpenter in Dall, 1879

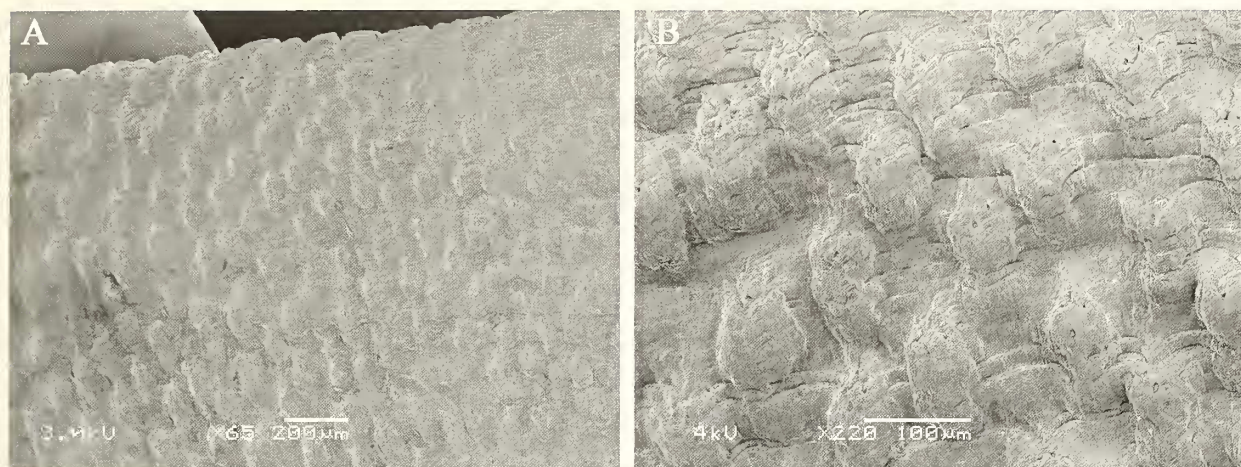
## Type species

*Deshayesiella* (*Leptochiton*) *curvatus* (Carpenter MS) Dall, 1879 (nom. nud., = *Lepidopleurus* (*Deshayesiella*) *curvatus* Carpenter in Pilsbry, 1892), by subsequent designation (Pilsbry, 1892).

*Deshayesiella sirenkoi* sp. nov.  
 (Figs. 3, 4, 5A-D)

## Type material examined

Holotype: NSMT-Mo 73841 (ex. JAMSTEC sample No.: RK8-B-1, 006983), body length 36.4 mm. Type locality: hy-



**Figure 2.** *Leptochiton tenuidentus* Saito and Okutani, 1991 (NSMT-Mo 73940) valve VI. A, sculpture on central area, scale bar = 200 µm; B, close-up of granules on central area, scale bar = 100 µm.

drothermal vent site on the Kasuga II Seamount in the northern Mariana Islands area, 21°36.1'N, 143°38.5'E, 400 m, 2K, Dive #986, 23 November 1997; paratypes: NSMT-Mo 73842, 1 specimen, body length ca. 45 mm, hydrothermal vent site on the Nikko Seamount in the northern Mariana Islands area, 23°04.7'N, 142°19.9'E, 460 m, 6K, Dive #144, 19 September 1992; NSMT-Mo 73843 (ex. JAMSTEC sample No.: FZ10, 061632-061635), 4 specimens, body length ca. 27-31 mm, hydrothermal vent site on the Daikoku Seamount in the northern Mariana Islands area, 21°19.53'N, 144°11.51'E, 428 m, on rock, HPD, Dive #498, 1 November 2005.

### Diagnosis

Valves thick, low, slightly carinated. Median valves wide, angulated at antero-lateral corners, weakly protruded at anterior margin of jugal area. Tail valve with slightly raised mucro located anterior to the center, and concave posterior slope. Pleural areas sculptured with longitudinal, weakly curving riblets. Girdle with long needles.

### Description

Body (Fig. 5A) oval, 36.4 mm in length. Valves (Fig. 5B) thick, low, slightly carinated. Girdle fleshy, deeply encroaching at sutures.

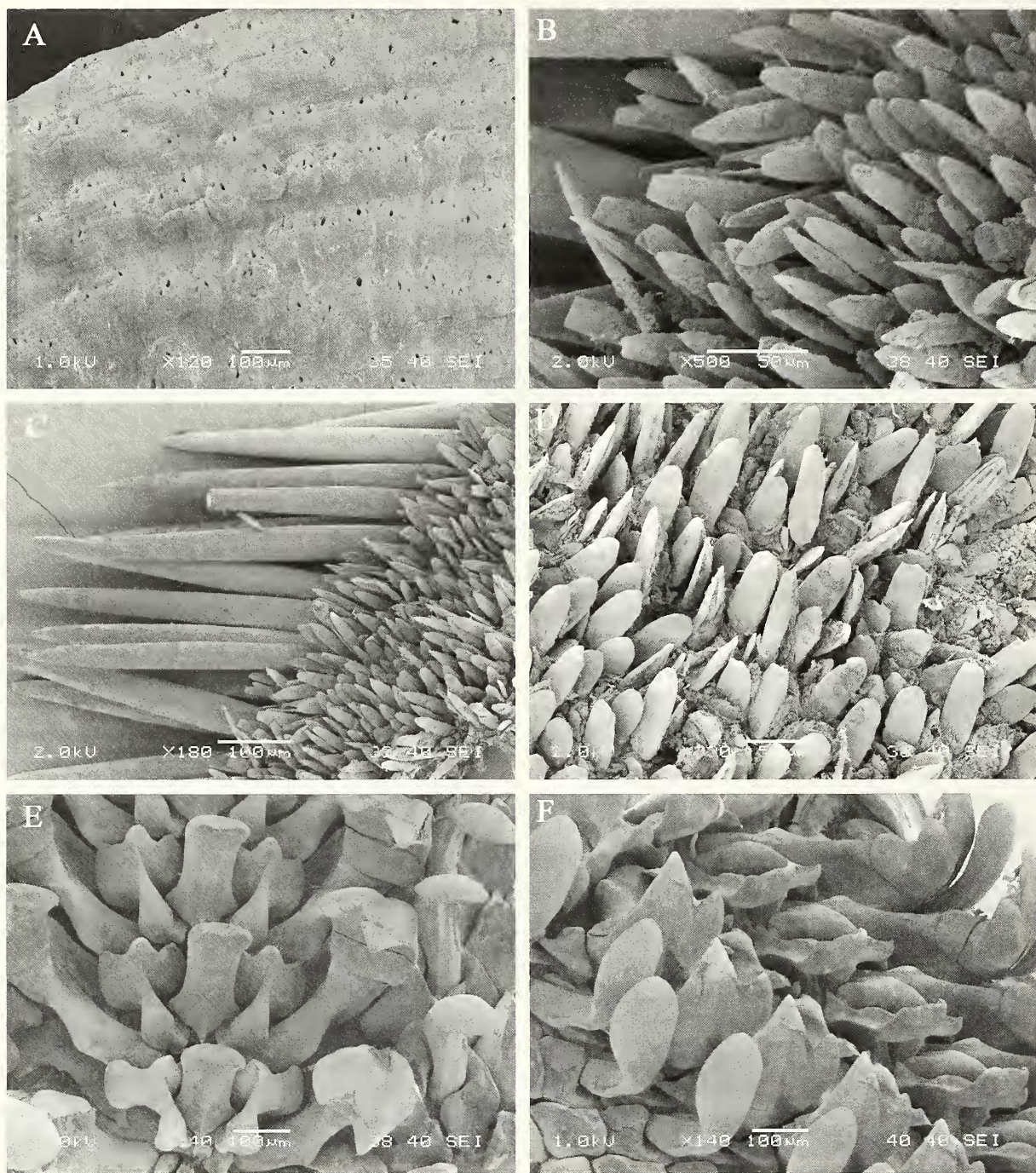
Head valve semicircular, rounded at postero-lateral corners. Median valves wide, widest at valves IV-VI, slightly carinated, beaked, weakly projected at anterior margin of jugal area. Tail valve more than semicircular, wider than head valve; mucro slightly raised, located anterior to the center; posterior slope concave. Tegmentum granulocostate. Head valve, lateral areas of median valves, and posterior area of tail valve sculptured with densely packed gran-

ules which are often fused radially, forming larger elongate granules, marked with concentric growth lines; pleural areas of median and tail valves sculptured with strong, longitudinal, slightly curving riblets; jugal area densely sculptured with finer granules. Aesthete pores (Fig. 3A) located on anterior portion of each granule. Each group of pores consisting of one macroaesthete pore, 10-20 µm in diameter, and one or two microaesthete pores, 5-8 µm in diameter at both sides of macroaesthete pore. Articulamentum of head valve thickened, weakly projecting around the anterior margin of transverse muscle scars. Median valves and tail valve with widely V-shaped callus. Eaves wide, nearly smooth, scattered with minute aesthete pores. Tegmentum broadly folded under on posterior margin. Sutural laminae (Fig. 5B) strongly projected forward, triangular, widely separated from each other.

Girdle fleshy, thick, brownish. Perinotum (Figs. 3B, 5D) densely covered with elongate, obtusely pointed, flattened, distally ribbed spicules (Fig. 4A), 130 µm × 25 µm, intermingled with long, straight, smooth needles (Fig. 4B), up to 680 µm × 55 µm. Girdle margin fringed with long needles similar to those on perinotum (Fig. 3C). Spicules on hypinotum (Figs. 3D, 4C-E) flat with one to three strong riblets, 90 µm × 30 µm.

Gills merobranchial, adanal, without interspace, 16 on left, 18 on right.

Radula (Fig. 3E-F) long, 15.5 mm in length with 56 transverse rows of mineralized teeth. Central tooth oblong with narrow cusp at top, weakly expanded laterally, keeled near base. Centro-lateral (first lateral) teeth with well developed plate surrounding base of major lateral (second lateral) teeth, obtusely pointed at antero-dorsal corner. Major lateral teeth with bicuspid head, of which the larger outer cusp is



**Figure 3.** *Deshayesiella sirenkoi* sp. nov., holotype (NSMT-Mo 73841). A, valve II, granules on pleural area near anterior margin of jugal area, scale bar = 100 µm; B, spicules of perinotum near girdle margin, scale bar = 50 µm; C, marginal spicules, scale bar = 100 µm; D, spicules of hyponotum, scale bar = 50 µm; E, radula, central part, postero-dorsal view, scale bar = 100 µm; F, radula, central part, oblique antero-dorsal view, scale bar = 100 µm.

pointed and the smaller, inner cusp is rounded. Major uncinus (fifth lateral) teeth rounded at top with blade of moderate width. Bolster (radular vesicle and cartilage) length 5.2 mm.

#### Distribution and type of habitat

Known from the seamounts on Kasuga II, Nikko, and Daikoku in the northern Mariana Islands area, 400-460 m; hydrothermal vent.

### Etymology

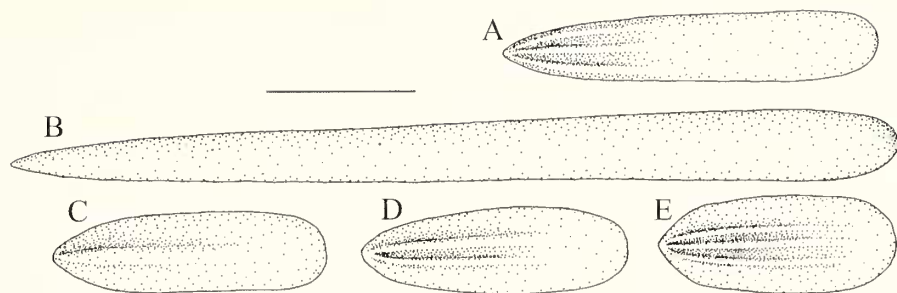
This species is named in honor of Dr. Boris Sirenko, who has recently given a new diagnosis for the genus *Deshayesiella*.

### Remarks

The features of the present species match the characteristics of *Deshayesiella* given by Sirenko (1997). These features include: valves solid, rather flat, evenly rounded; median valves divided into jugal, two pleural, and two lateral areas (unlike *Leptochiton*); tegmentum of head valve, lateral area of median valves and postmucronal area of tail valve sculptured with irregular granules, strongly marked with concentric lines of growth; girdle rather wide, dorsally covered with small spicules (100–150  $\mu\text{m}$ ) and randomly dispersed large spines (320–550  $\mu\text{m}$ ); radula with bicuspid major lateral teeth. Although there are some slight differences, such as the slightly carinated valves and somewhat longer large perinotal spines in the present species, we think they are insignificant for generic assignment. Sirenko (1997) recognized three known species in *Deshayesiella*: *D. curvata* (Carpenter in Pilsbry, 1892), *Oldroydia bidentata* Is. Taki, 1938, and *Hanleya sinica* Xu, 1990, as well as two undescribed species (sp. 1 and 2). The assignment of *H. sinica* may, however, need reconsideration because it has rather vaguely regionalized tegmentum with finer sculpture, and thus is more like members of *Leptochiton* in this respect. The present species is easily distinguishable from all known congeners and one of Sirenko's undescribed species, sp. 1, in having wider median valves, each side with more angular antero-lateral corner. The features of another undescribed species, sp. 2, have not yet been given in detail; however, the present new species is probably distinct from Sirenko's sp. 2 because the latter is distributed in a different geographic area: the East Pacific off southern California and in the Gulf of California, Mexico.

*Deshayesiella sirenkoi* is locally common around the hydrothermal vent site on the Daikoku Seamount (see Fig. 5C). *Deshayesiella sirenkoi*, as well as two known vent species, *Leptochiton tenuidentatus* Saito and Okutani, 1990 and *Thermochiton undocostatus* Saito and Okutani, 1990 could be restricted to hydrothermal vent and/or methane seep habitats because each of these species was found only from those environments of more than two sites.

Order Chitonida Thiele, 1909  
Suborder Chitonina Thiele, 1909  
Family Ischnochitonidae Dall, 1889  
Genus *Thermochiton* Saito and Okutani, 1990



**Figure 4.** *Deshayesiella sirenkoi* sp. nov., holotype (NSMT-Mo 73841). A, spicule of perinotum; B, needle on perinotum; C-E, spicules of hyponotum; scale bar = 50  $\mu\text{m}$ .

### Type species

*Thermochiton undocostatus* Saito and Okutani, 1990, by original designation.

*Thermochiton undocostatus* Saito and Okutani, 1990

*Thermochiton undocostatus* Saito and Okutani 1990: 171–174, figs. 13–23, pl. 2, figs. 1–4; Kaas and Van Belle 1994: 36–38, fig. 13; Kaas and Van Belle 1998: 192; Saito 2000: 11, pl. 6, fig. 12; Cosel 2006: 80.

### Type material examined

Holotype: NSMT-Mo 69194, body length ca. 13 mm. Type locality: hydrothermal vent site on the Iheya Ridge, central Okinawa Trough, East China Sea, 27°32.70'N, 126°58.20'E, 1395 m, 2K, Dive #426, 21 July 1989.

### Additional material examined

NSMT-Mo 73844 (ex. JAMSTEC sample No.: RK4-A-6, 038998-039004), 6 specimens, body length ca. 3–8 mm, Hydrothermal vent site on the Hatoma Knoll, 24°51.65'N, 123°50.29'E, 1497 m, on small chimney rock, 2K Dive #1277, 29 May 2001; NSMT-Mo 73845, 2 specimens, body length ca. 7 mm, methane seep site on the Kuroshima Knoll off Yaeyama Islands area, 24°08.00'N, 124°11.50'E, 686–688 m, on the shells of *Bathymodiolus hirtus* Okutani, Fujikura, and Sasaki, 2004 or *Bathymodiolus securiformis* Okutani, Fujikura and Sasaki, 2004, and *Calypptogena kawamurai* (Kuroda, 1943), HPD, Dive #554, 21 May 2002.

### Additional description

Gills nearly holobranchial (anterior-most gill located under the third valve), adanal, with interspace, 19 gills on each side (NSMT-Mo 73845).

### Distribution and type of habitat

Off southern Nansei Islands, 686–1497 m; hydrothermal vent and methane seep.

### Remarks

Characteristic features of the present specimens, such as undulating sculpture on the valves, granulo-costate dorsal



**Figure 5.** New species of chitons. A-D, *Deshayesiella sirenkoi*; E-H, *Placiphorella okutanii*; I-K, *Placiphorella isaotakii*. A, E, I, whole animal, dorsal view, holotypes; B, F, J, head, median (B: valve II; F, J: valve III), and tail valves, dorsal view, holotypes, scale bar = 5 mm; C, habitat, Daikoku Seamount, arrow heads indicate position of chitons; D, perinotum, showing long needles, holotype, scale bar = 1 mm; G, tail valve, paratype, scale bar = 1 mm; H, K, anterior margin of girdle, paratype and holotype, respectively, scale bar = 1 mm.

scales, and head of the major lateral tooth of radula with basal pointed projection agree well with those of the holotype.

Suborder Acanthochitonina Bergenhayn, 1930

Family Mopaliidae Dall, 1889

Genus *Placiphorella* Dall, 1879

Type species

*Placiphorella velata* (Carpenter MS) Dall, 1879, by original designation.

*Placiphorella okutanii* sp. nov.

(Figs. 5E-H, 6, 7)

*Placiphorella stimpsoni*: Wu and Okutani 1985: 126-128, figs. 9-18 (not of Gould 1859).

### Type material examined

Holotype: NSMT-Mo 73777 (ex. JAMSTEC sample No.: RK4-B-5, 006454), body length 32 mm. Type locality: Hachijo Depression in the Izu-Ogasawara (Bonin) Islands area. 32°48.8'N, 139°27.0'E to 32°51.3'N, 139°31.6'E, 926-817 m, dredge attached to JAMSTEC Deep Tow Camera, cruise No.: DK88-3-IZU, 27 August 1988; paratype: NSMT-Mo 60008, body length ca. 30 mm, off Miyake Island, Izu-Ogasawara Islands area, 34°03.0'N, 140°02.2'E, 1210-1235 m, R/V *Soyo-Maru* St. B2, beam trawl, 5 July 1967.

### Diagnosis

Valves chalky white, fragile, sculptured with densely packed, low, rather large, granules. Tail valve with narrow postmucronal areas separated by shallow sinus behind mucro. Sutural laminae wide, narrowly separated from each other. Perinotum densely implanted with low spiny tufts. Bristle implanted around girdle margin.

### Description

Body (Fig. 5E) broadly oval, 32 mm in length, light buff in color.

Valves (Fig. 5F) wide, depressed, subcarinated, chalky white, fragile. Head valve crescent in outline, anterior slope concave. Median valves very wide, short, oblong in outline, weakly projected forward at jugal portion; lateral areas raised, grooved medially. Tail valve (Fig. 6A) small, inversed trapezoidal in outline, with narrow postmucronal area separated by shallow sinus at posterior end; mucro subterminal, slightly raised. Tegmentum (Fig. 5F) sculptured with densely packed, low, somewhat elongate granules on head valve, lateral areas of median valves, and postmucronal area of tail valve. Remaining tegmental areas with slightly lower, larger granules. Aesthete pores minute, 3-6  $\mu\text{m}$  in diameter, distributed both on granules and the tegmental plain (Fig. 6B), which become denser toward the lateral areas (Fig. 6D). The

difference between macroaesthete pore and microaesthete pore hardly discernible. Articulamentum well developed, white, heavily calloused anteriorly in head valve, transversely in median valve, and posteriorly in tail valve; posterior margin of articulamentum widely covered with folded tegmentum in head and median valves, narrowly covered in tail valve. Sutural laminae well developed, narrowly separated from each other. Insertion teeth short, thick, rugose on anterior surface, with 12 slits in head valve (Fig. 6C), one on each side in median valves, none on tail valve. Slit rays represented by series of minute pores, clearly visible in apical half of head valve, median valves, inconspicuous in tail valve. Eaves narrow, with many minute pores.

Girdle (Fig. 5E) widely expanded anteriorly, becoming narrower toward posterior end. Perinotum (Fig. 6E) covered with minute spicules (Fig. 7A-B), mammilated at tip, ca. 150  $\mu\text{m} \times 30 \mu\text{m}$ , and densely implanted with low spiny tufts consist of 5-10 sharply pointed, weakly curved spicules (Fig. 7C-D), ca. 400  $\mu\text{m} \times 50 \mu\text{m}$  in width, surrounded by broken short spicules. Bristle, worn off in holotype, with sharply pointed spicules similar to spiny tufts. Hyponotum clothed with obtusely pointed, smooth spicules (Figs. 6F, 7G), 140-165  $\mu\text{m} \times 30 \mu\text{m}$ . Anterior hyponotum with numerous warts, which are provided with 20-30 pointed spicules (Fig. 7H-I), 150-170  $\mu\text{m} \times 25 \mu\text{m}$ . Pallial fold well developed with 9 precephalic tentacles, which are occasionally bifurcated. Spicules on pallial fold similar to obtusely pointed spicules on hyponotum, but smaller on precephalic tentacles, 110  $\mu\text{m} \times 15 \mu\text{m}$  (Fig. 7J), somewhat narrower on posterior end, 160  $\mu\text{m} \times 25 \mu\text{m}$  (Fig. 7K).

Gills holobranchial, abanal, with interspace, 15 on left side, 16 on right.

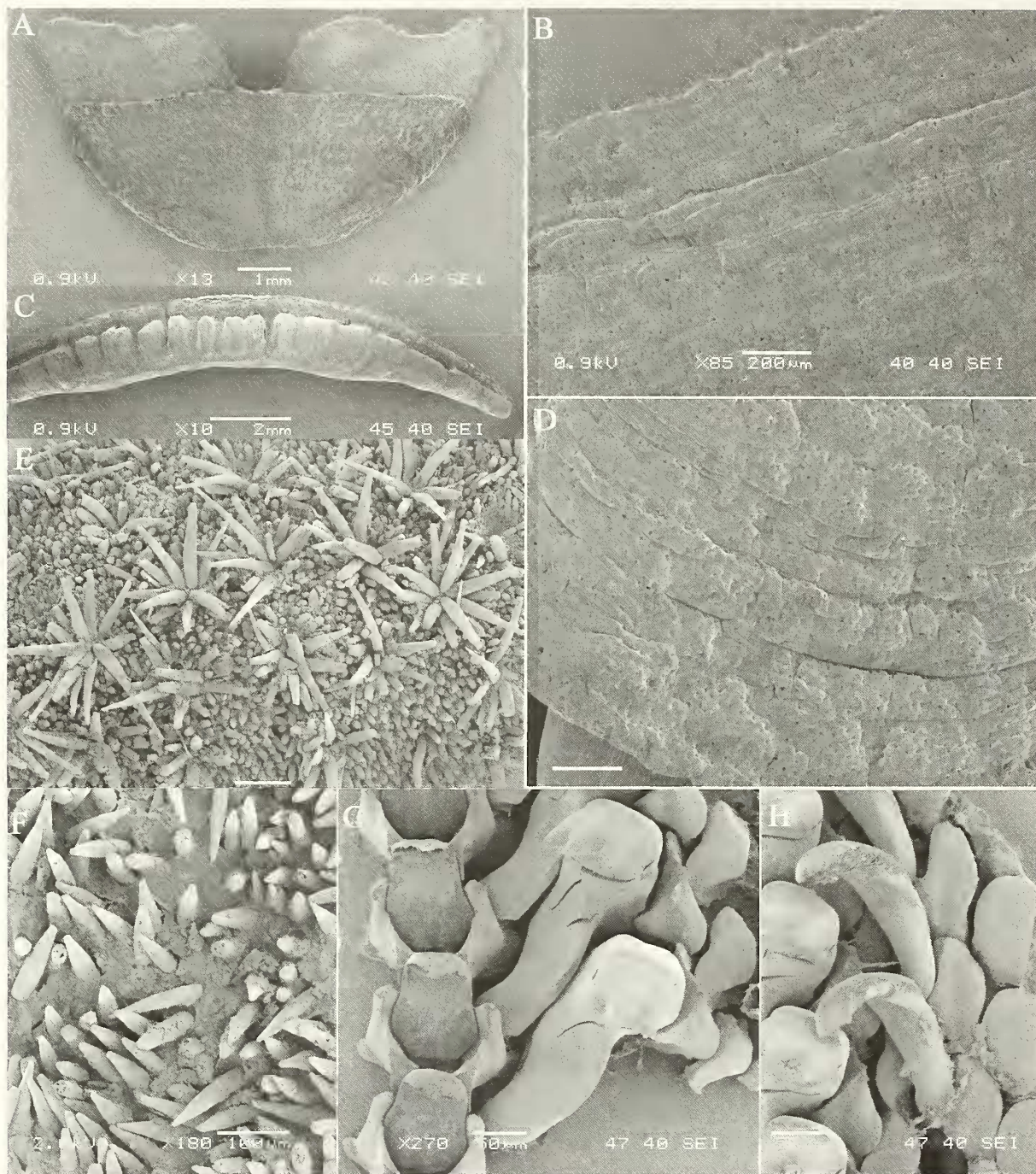
Radula (Fig. 6G-H) small, 6.5 mm in length, with 40 transverse rows of mineralized teeth. Central tooth oblong, with narrow cutting edge, slightly expanded laterally and bilobed at base. Centro-lateral (first lateral) teeth low, thickened at antero-dorsal corner. Major lateral (second lateral) teeth with proportionally small tridentate head. Major uncinus (fifth lateral) teeth with rather long blade of moderate width. Bolster (radular vesicle and cartilage) length 3.3 mm.

*Paratype*: Tail valve (Fig. 5G) with narrow posterior areas separated by shallow sinus at posterior end.

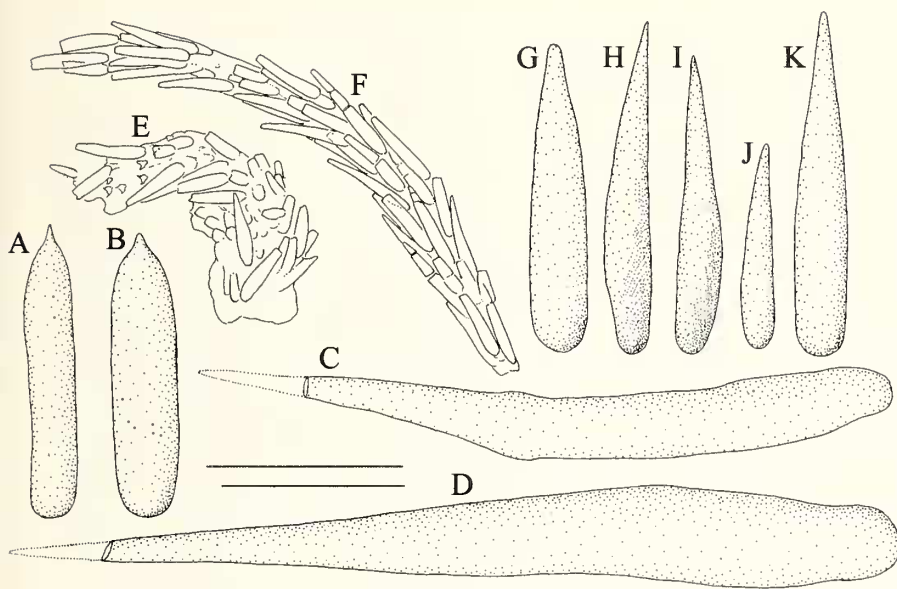
Bristle densely implanted along girdle margin (Fig. 5H). Thick bristles (Fig. 7E), ca. 300  $\mu\text{m}$  in width, implanted on girdle margin and apparently thinner bristles (Fig. 7F), attaining ca. 1 mm  $\times$  100  $\mu\text{m}$ , restricted on dorsal surface close to girdle margin, and occasionally on other area on perinotum.

### Distribution and type of habitat

Only known from Hachijo Depression and off Miyake Island in Izu-Ogasawara Islands area, 817-1235 m; un-



**Figure 6.** *Placiphorella okutanii* sp. nov., holotype (NSMT-Mo 73777). A, tail valve, scale bar = 1 mm; B, tegmentum of valve III, anterior margin of central area, scale bar = 200  $\mu$ m; C, insertion teeth of head valve, scale bar = 2 mm; D, tegmentum of valve III, lateral area, scale bar = 200  $\mu$ m; E, anterior perinotum, scale bar = 200  $\mu$ m; F, spicules of hyponotum, scale bar = 100  $\mu$ m; G, radula, central part (right half), postero-dorsal view, scale bar = 50  $\mu$ m; H, radula, lateral part, postero-dorsal view, scale bar = 50  $\mu$ m.



**Figure 7.** *Placiphorella okutanii* sp. nov., sclerites, A-D, G-K, holotype (NSMT-Mo 73777); E, F, paratype (NSMT-Mo 60008). A, B, spicules of perinotum; C, D, spicules of tuft on perinotum; E, thick bristle (spicules are lost in large part); F, thin bristle; G, spicules of hyponotum, H, I, spicules of tuft on hyponotum; J, spicule of precephalic tentacle; K, spicule of pallial fold near posterior end. Upper scale bar = 100  $\mu$ m, for A-D, G-K; lower scale bar = 500  $\mu$ m, for E and F.

known, possibility of hydrothermal activity is suggested in Hachijo Depression.

### Etymology

This species is named in honor of Dr. Takashi Okutani, who has been actively working for deep-sea vent/seep molluscs, and collected this species for the first time.

### Remarks

Kaas and Van Belle (1994) synonymized all known deep-sea *Placiphorella* species with *Placiphorella atlantica* (Verrill and Smith, 1882) and this decision was followed by Clark (1994). However, at least *Placiphorella pacifica* Berry, 1919 and *Placiphorella albitestae* Is. Taki, 1954 are distinctive, and can be separated by the valve shape and sculpture, girdle element shape and sclerite arrangement, and other features. Among those deep-sea *Placiphorella*, the present new species most closely resembles *Placiphorella "pacifica"* reported by Smith and Hanna (1952) from Pioneer Seamount, East Pacific, 500-650 m (CASIZ 064802) by having granular tegmentum. However, the granules of the former are irregular in shape and arrangement, especially on the lateral areas, and the spiny tufts of the perinotum are very prominent and dense. *Placiphorella "pacifica"* reported by Smith and Hanna (1952) can be an undescribed species be-

cause *P. pacifica* Berry, 1919 (Lectotype, SBMNH 34394 designated by Scott *et al.* 1990) has almost smooth surface on the tegmentum, and no other known species of *Placiphorella* has such an obviously granular tegmentum. From Japanese waters, another deep-sea species, *Placiphorella albitestae* was described from the Sagami Sea, northern Izu-Ogasawara Islands area. *Placiphorella albitestae* has much finer granules on finer, but sharply raised, growth lines on the tegmentum, much finer and scarce spinous tufts on the perinotum, and shallower bathymetrical range of distribution, from 80 to 200 m (Saito 2000).

### *Placiphorella isaotakii* n. sp. (Figs. 5I-K, 8, 9)

#### Type material examined

Holotype: NSMT-Mo 73778 (ex. JAMSTEC sample No.: RK4-A-3, 016481), body length ca. 34 mm. Type locality: methane seep sites on the Kuroshima Knoll off Yaeyama Islands area, 24°07.00'N, 124°11.00'E, 691-692 m, 2K, Dive #1100, 22 May 1999.

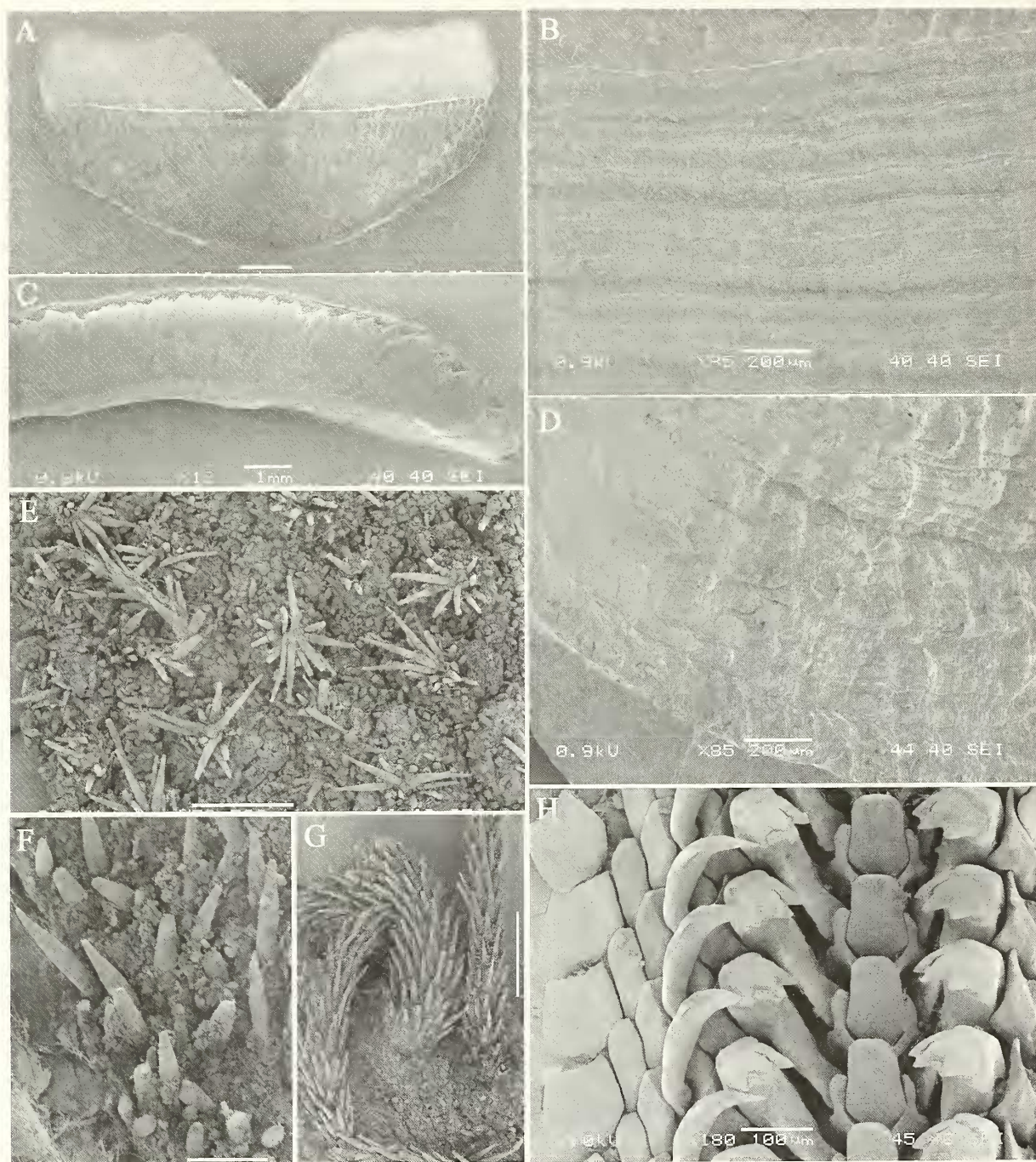
### Diagnosis

Valves solid, sculptured with fine elongate granules. Tail valve wide triangular, with terminal mucro. Sutural laminae wide, narrowly separated each other. Insertion teeth low, hardly separated with slits in head valve. Perinotum densely implanted with low spinous tufts. Bristle implanted along girdle margin.

### Description

Body (Fig. 5I) broadly oval, ca. 34 mm in length, light buff in color.

Valves (Fig. 5J) wide, depressed, subcarinated, solid. Head valve crescent in outline; anterior slope concave. Median valves very wide, short, oblong in outline, weakly projected forward at jugal portion; lateral areas raised, grooved medially. Tail valve (Fig. 8A) small, wide triangular in outline, with terminal mucro. Tegmentum (Fig. 5J) sculptured with densely packed, elongate granules on head valve and lateral areas of median valves. Remaining tegmental areas with weak, elongated granules, which are occasionally merged into longitudinal threads. Aesthete pores minute, 3-5  $\mu$ m in diameter, arranged roughly in concentric patterns



**Figure 8.** *Placiphorella isaotakii* sp. nov., holotype (NSMT-Mo 73778). A, tail valve, scale bar = 1 mm; B, tegmentum of valve III, anterior margin of central area, scale bar = 200  $\mu$ m; C, insertion teeth of head valve, scale bar = 1 mm; D, tegmentum of valve III, lateral area, scale bar = 200  $\mu$ m; E, perinotum, scale bar = 500  $\mu$ m; F, spicules of hyponotum, scale bar = 100  $\mu$ m; G, bristles near anterior margin, scale bar = 500  $\mu$ m; H, radula, postero-dorsal view, scale bar = 100  $\mu$ m.

in pleural areas (Fig. 8B), which are denser and less regularly arranged on lateral areas (Fig. 8D). Difference between macroaesthete pore and microaesthete pore hardly discernible. Articulamentum well developed, white, heavily calloused ante-

riorly in head valve, transversely in median valve, and posteriorly in tail valve; posterior margin of articulamentum widely covered with folded tegmentum in all valves. Sutural laminae well developed, narrowly separated from each other.

Insertion teeth low, thick, rugose on outside. Slits inconspicuous on head valve (Fig. 8C), one on each side in median valves, none in tail valve. Slit rays inconspicuous, represented by minute pores. Eaves narrow, with minute pores.

Girdle (Fig. 5I) widely expanded anteriorly, becoming narrower toward posterior end. Perinotum (Fig. 8E) covered with minute, thick spicules (Fig. 9A-B), obtuse or weakly mammillated at tip,  $150\ \mu\text{m} \times 40\ \mu\text{m}$ , and densely implanted with low spinous tufts consist of 5-10 sharply pointed spicules (Fig. 9C-D),  $440\ \mu\text{m} \times 50\ \mu\text{m}$  surrounded by broken short spicules. Thick bristle (Figs. 8G, 9E), up to  $2.5\ \text{mm} \times 400\ \mu\text{m}$ , implanted along the girdle margin, while thinner bristle (Fig. 9F) restricted on dorsal surface close to girdle margin (Fig. 5K) and occasionally on other area of perinotum. Spicules on bristle similar to those of tufts, but less curved and slightly shorter,  $380\ \mu\text{m} \times 50\ \mu\text{m}$ . Hyponotum clothed with obtusely pointed, smooth spicules (Figs. 8F, 9G-H), attaining  $180\ \mu\text{m} \times 30\ \mu\text{m}$ . Anterior hyponotum with numerous warts which are provided with 20-40 pointed spicules (Fig. 9I),  $150\text{-}170\ \mu\text{m} \times 25\ \mu\text{m}$ . Pallial fold well developed with nine precephalic tentacles, which are occasionally bifurcated. Spicules on pallial fold similar to obtusely pointed spicules on hyponotum, but smaller on precephalic tentacles,  $120\ \mu\text{m} \times 15\ \mu\text{m}$  (Fig. 9J), somewhat narrower on posterior end,  $165\ \mu\text{m} \times 25\ \mu\text{m}$  (Fig. 9K).

Gills holobranchial, abanal, with interspace, 21 on left side, 22 on right.

Radula (Fig. 8H) small, 7.5 mm in length, with 41 transverse rows of mineralized teeth. Central tooth oblong, with narrow cutting edge, slightly expanded laterally and bilobed at base. Centro-lateral (first lateral) teeth low, thickened at antero-dorsal corner. Major lateral (second lateral) teeth with small tridentate head. Major uncinus (fifth lateral) teeth with rather long blade of moderate width. Bolster (radular vesicle and cartilage) length 3.4 mm.

### Distribution and type of habitat

Known only from the type locality; methane seep.

### Etymology

This species is named in honor of the late Dr. Isao Taki, who described the first deep-sea *Placiphorella*, *P. albitestae* from Japanese waters.

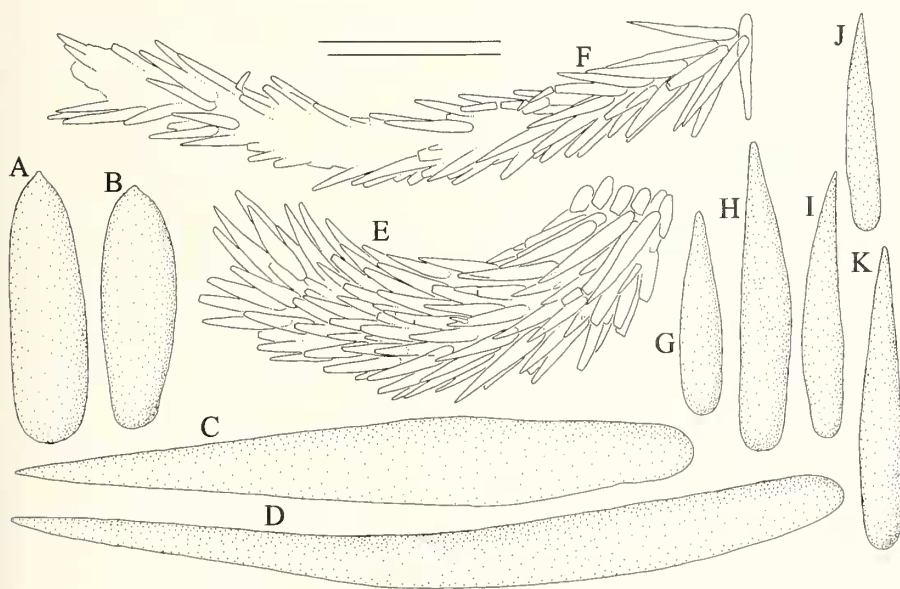
### Remarks

This species also resembles *Placiphorella* "*pacifica*" reported by Smith and Hanna (1952) and the preceding new species, *Placiphorella* by having a granular tegmentum; however, the present species differs by having a terminal mucro on a wider tail valve, and thread-like sculpture of the central area.

The two new *Placiphorella* species described here might be transient species, rather than vent/seep specialists because *Placiphorella* species have been shown to be carnivorous, using their anterior expanded girdle to trap prey (McLean 1962, Saito and Okutani 1992). They may be able to live in non-chemosynthetic environment if enough prey were available.

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**Figure 9.** *Placiphorella isaotakii* sp. nov., sclerites, holotype (NSMT-Mo 73778). A, B, spicules of perinotum; C, D, spicules of tuft on perinotum; E, thick bristle; F, thin bristle (some parts are not traced due to foreign deposit); G, H, spicules of hyponotum; I, spicules of tuft on hyponotum; J, spicule of precephalic tentacle; K, spicule of pallial fold near posterior end. Upper scale bar =  $100\ \mu\text{m}$ , for A-D, G-K; lower scale bar =  $500\ \mu\text{m}$ , for E, F.

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